

Bodily immunity to error^{*}

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Self-ascription of a property is said to be immune to error through misidentification relative to the first-person if and only if one cannot be mistaken about the person who instantiates the property when one has gained information about the property in the appropriate way (although one can be mistaken about the property one ascribes to oneself) (Evans, 1982). For instance, if I think that I am anxious because I feel anxious, my thought is immune to error through misidentification of the subject. But if I think that I am anxious because my psychoanalyst told me so, my thought is not immune to error. Indeed, the psychoanalyst may have confused me with another patient, who is the person suffering from anxiety. To be immune, my thought must be grounded in introspection, that is, on a way of gaining information about one's mental states *from the inside*.

Most accounts of immunity to error through misidentification relative to the first-person (hereafter, IEM) have focused on self-ascriptions of mental states (e.g., belief, desire, emotion) (e.g., Shoemaker, 1968; Campbell, 1999; Wright, 1998; Peacocke, 1999). Arguably, one may suggest a similar account of self-ascription of the physical properties of one's own body¹ (e.g. body size, weight, posture, etc.). By bodily self-ascription, I do not mean the ascription of bodily sensations. Bodily sensations are mental states, like emotions, beliefs or desires. By bodily self-ascription, I mean the ascription of bodily properties. One may then suggest that not only self-ascriptions of mental states, but also self-ascriptions of bodily properties can be immune to error through misidentification, if appropriately grounded. Three questions follow. First, what are the appropriate grounds that can secure bodily IEM? Second, do bodily

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¹ By one's body, I shall assume one's body as defined in biology, and I shall not inquire further in the metaphysical question of what makes a body one's own.

self-ascriptions display the same type of IEM as mental self-ascriptions? Third, does bodily IEM reveal the bodily nature of the self? Here I shall focus on the first question.

According to what I call the Inside mode account, bodily self-ascriptions are immune to error through misidentification if and only if one gains information about the body *from the inside* (e.g. proprioception, sense of pressure and sense of balance).² For instance, I may judge that my arms are crossed on the grounds that I feel from the inside through proprioception that my arms are crossed. I may be mistaken about my bodily posture (e.g., my arms are not crossed), but can I doubt that those are my arms that I feel crossed? Intuitively, it seems unlikely. Indeed, through proprioception one has a privileged internal access to one's body that one does not have for other bodies. Therefore, if one gains information that the arms are crossed via proprioception, one cannot rationally doubt that those are one's own arms that are crossed.

However, recent empirical evidence has revealed cases of patients suffering from somatoparaphrenia who do doubt whether this is their own arm, despite the fact that they experience their arm from the inside. Conversely, it was shown that one can be easily induced to self-ascribe bodily properties that are instantiated by a fake hand (i.e. the Rubber Hand Illusion). In both cases, one misidentifies whose hand it is, whether one attributes one's own hand to another individual or self-attributes an external hand. At first sight, those cases might be considered as empirical evidence against the Inside mode account of bodily IEM. However, as we shall see, they do not offer fatal objections against bodily IEM, but rather invite us to redefine the grounds that guarantee bodily IEM. In particular, I shall highlight the multimodal nature of bodily self-knowledge, and assess its implications for bodily IEM.

1. The hypothesis of bodily IEM

There is little agreement on the interpretation of IEM, whether it concerns self-ascriptions of mental states or of bodily properties. One may analyse IEM in logical,

² Versions of the Inside mode theory have been defended by Evans (1982), Brewer (1995), Martin (1995), Bermudez (1998), Dokic (2003), Recanati (2007) to various extent.

epistemological or psychological terms. I shall not review the differences between each interpretation here, nor argue in favour of one rather than the other. Rather, I shall assume an epistemological interpretation of bodily IEM such that IEM derives from the rational structure of bodily self-knowledge. According to the Inside mode account of bodily IEM, there is an epistemic difference between the perception of the body from the inside and the perception of the body from the outside. On this view, somatic perception guarantees bodily IEM, whereas vision do not.

As noted by Wittgenstein (1958), I can see an arm broken, but this does not entitle me to believe that my own arm is broken. It might be another person's arm that is intermingled with mine. I may be mistaken about whose arm is broken because I can see many other people's arms, as well as my arms. Vision can take different bodies as its object. It is not restricted to taking one's own body as its sole object. By contrast, there are some anatomical constraints such that proprioception, touch, the sense of balance, and the sense of temperature (hereafter called somatic perception) give access exclusively to one's own body. They guarantee that if one gains information through such informational channel, it is about one's own body. Proprioceptive experiences suffice to justify bodily self-ascriptions such that no intermediary process of self-identification is required. For instance, the judgment "my arms are crossed" is not grounded in the judgment "those arms are crossed" and in the identification "those arms are mine". One cannot doubt that the arms that are crossed are one's own when one knows the position of the arms through proprioception:

"We have what might be described as a general capacity to perceive our own bodies, although this can be broken into several distinguishable capacities: our proprioceptive sense, our sense of balance, of heat and cold, and of pressure. Each of these modes of perception appears to give rise to judgments which are immune to error through misidentification. (...) There just does not appear to be a gap between the subject's having information (or appearing to have information), in the appropriate way, that the property of being F is instantiated, and his having information (or appearing to have information) that he is F." (Evans, pp. 220-221)

The anatomical constraints that secure the link between somatic perception and one's body might be override in the future if, for instance, one's brain can be connected to another individual's body. One would then feel from the inside the

other's bodily states and postures. If so, knowing that the arms are crossed via proprioception no longer guarantees that those are one's arms that are crossed. In this scenario, bodily self-ascriptions grounded in somatic perception would not be immune to error. However, I shall leave this type of futuristic scenario aside, and focus on actual cases of misidentification here.

Pryor (1999) distinguishes between two types of misidentification, *de re* misidentification and which-object misidentification, as illustrated below:

De re misidentification: I have the illusory experience of touching a piece of cloth. I cannot directly see my own hands, but I see in a mirror several people touching pieces of cloth. I judge that I am identical to a person that I see in the mirror who looks like me and who is touching a piece of cloth. However, this is not me and I am not touching a piece of cloth.

Which-object misidentification: I smell a skunky odour in my garden and I see several animals in my garden, although none of them looks like a skunk. I identify by the odour that the smallest of the animals is a skunk. However, this animal is not a skunk, although it was true that there are skunks in my garden.

Both cases involve misidentification, but of different kinds. In the first case, my self-ascription that I am touching a piece of cloth rests on my justification to believe that I am the person in the mirror and on the singular proposition that the person in the mirror is touching a piece of cloth. However, unbeknownst to me, I am not this person. In the second case, the odour that I smell, which comes from a skunk, justifies me in believing the existential generalization that there are skunks in my garden. The same odour also justifies me (or so do I believe) in identifying which animal is the skunk. However, the animal I single out is not the skunk. What matters here is that my grounds derive in the right way from the skunk that is in my garden, and this is why they offer me the existential generalization that there are skunks in my garden. In a nutshell, there is *de re* misidentification when one makes a false identification assumption about two particular objects such that $y = x$, whereas there is which-misidentification when one is justified in making an existential generalization such that there is an a that is F, although one is wrong in figuring out which object

instantiates the property F. From these two types of misidentification, follow two types of IEM.³

In terms of bodily self-ascriptions, this distinction leads us to two possible scenarios. First, I may believe that my body instantiates the bodily property F because I believe that my body is the particular body that I see in the mirror for instance. That would be a case of *de re* (mis)identification. Second, I may believe that there is a body that instantiates the bodily property F and I believe that this is my body that instantiates this property. That would be a case of which-body (mis)identification.

In the following sections, I shall analyse two cases of misidentification: somatoparaphrenia interpreted in terms of which-misidentification and the Rubber Hand Illusion interpreted in terms of *de re* misidentification. I shall assess whether those two cases constitute counterexamples for the Inside mode account of bodily IEM.

2. It's not mine

“Examiner: Whose arm is this? AR: It's not mine. Ex: Whose is it? AR: It's my mother's. Ex: How on earth does it happen to be there? AR: I don't know. I found it in my bed. (...) Ex: So, where is your left arm? AR: It's under there (indefinite gesture forwards) (...) Look, it's queer, but that's how it is. Just fancy finding your son's arm in your bed” In Bisiach et al. (1991, p. 1030)

The patient AR suffers from somatoparaphrenia (also sometimes called asomatognosia), a neuropsychological condition that follows a brain lesion or an epileptic seizure in the parietal lobe of the right hemisphere. It is characterized by a denial of ownership of one's own limbs, and sometimes by the attribution of the limb to another individual, although she may not even be in the room (for review, see Vallar and Ronchi, 2009). The delusional belief can be so strong that the patients will maintain it despite correction: “Feinberg: Suppose I told you this was your hand? Mirna: I wouldn't believe you” (Feinberg et al., 2005, p. 104). Failure of bodily self-ascription can also be found in patients with depersonalization disorder (Sierra, 2001),

³ I shall not go here into the debate of what type of IEM is the most interesting, and equally investigate both of them (see for instance Smith, 2006).

with peripheral deafferentation (Cole, 1995), and with Body Integrity Identity disorder (Bayne and Levy, 2005). In the latter case, the feeling of bodily estrangement can be so vivid that patients experience an overwhelming desire to be amputated of their ‘alien’, though perfectly healthy, limbs. For these patients, the question ‘are you sure that this is your own body?’ does make sense. And they reply the negative. Their denial of bodily ownership cannot be ruled out as a mere metaphorical statement. Not only do they believe that this is not their own hand, but they also vividly experience it, or so they claim.

One may expect that they no longer experience their hand as their own because they no longer have bodily sensations in it. Sometimes one wake up during the night with a ‘sleeping’ arm, which feels almost like an alien object. The lack of bodily experiences from the inside may then explain the lack of bodily self-ascription. However, this is not the case in somatoparaphrenia. Somatoparaphrenic patients do not always feel numb or anaesthetized in the ‘alien’ limb. For example, when they are touched with a paintbrush or pinpricked, they can feel the touch or the pinprick (Melzack, 1990; Moro et al., 2004). Yet, they fail to self-ascribe the hand that they feel being touched. When asked how it was possible to feel touch on someone else’s hands, one of them replied: “many strange things can happen in life” (Moro et al., 2004, p. 440). Hence, the patients have the appropriate grounds (namely, tactile sensations) that entitle them to self-ascribe the hand that is in contact with the paintbrush, and yet, they do not judge that the hand in contact with the paintbrush is part of their own body. Rather, they may attribute the hand to their niece for instance (Bottini, et al., 2002).

One may interpret this error as an error through which-misidentification. The tactile sensations experienced on the hand justify the patients in making an existential generalization such that there is a hand that is in contact with a paintbrush. However, the patients are wrong in figuring out which object instantiates the bodily property because they do not judge that it is their own hand that is in contact with a paintbrush. If this is the right analysis of somatoparaphrenia, then it constitutes counter-evidence to the hypothesis of bodily immunity to error through which-misidentification. However, as I shall show, somatoparaphrenia is irrelevant for the discussion of bodily IEM for two distinct reasons.

First, when patients attribute the hand that they feel in contact with the paintbrush to one of their relatives, they make what one may call a false-negative error. There is a *false negative* if one does not self-ascribe properties that are instantiated by one's own body. False-negative errors have to be contrasted from false-positive errors. There is a *false positive* if one self-ascribes properties that are instantiated by another individual's body. The hypothesis of IEM clearly concerns false positives. It states that one cannot doubt that this is one's own body if one gains information about it in the appropriate way. It is, however, more controversial whether the hypothesis of IEM makes any claim about false negatives, such as somatoparaphrenia.⁴ The patients have the appropriate grounds that guarantee the IEM of self-ascriptions (e.g., they have tactile experiences), if self-ascriptions were to be made. But the presence of the appropriate grounds does not suffice to guarantee that the patients do make those self-ascriptions. The fact that they do not make the self-ascriptive judgment does not challenge the validity of the grounds. The patients may indeed have other reasons that they take to defeat their grounds. What is at stake then is to understand what these other reasons are (e.g., a vivid experience of disownership towards their hand). This question is of great interest if one aims at offering an account of the experience of bodily ownership and disownership. But it is not relevant for the discussion of bodily IEM. The hypothesis of bodily IEM claims that if the judgment derives from the right grounds, then it is immune to error. It does not make any claim about whether one makes the judgment or not. Roughly, it is not merely because one has plenty of good reasons to believe that *p* that one believes that *p*. And it is not because one does not believe that *p* that one does not have the good reasons for believing that *p*. One may have the appropriate ground to make the judgment that this is one's own hand, but that does not necessarily imply that one makes such judgment.

Alternatively, one may deny that the grounds upon which the patients based their judgments are appropriate. Put another way, the grounds upon which the patients make their judgment are not identical to the grounds that normally guarantee bodily IEM. As I shall later argue with the analysis of visual experiences, one should analyse the grounds for bodily IEM at the level of the perceptual content upon which the

⁴ Interestingly, the supposed counterexamples that have been proposed against IEM have always been false negatives, like thought insertion, anarchic hand sign and delusion of control (Campbell, 1999; Marcel, 2003).

judgment is made, rather than at the level of the individuation of the sensory modality (e.g., touch versus vision). In particular, I defended elsewhere that judgments of bodily ownership are grounded in the spatial content of bodily experiences that assigns a specific location to the bodily property (Vignemont, 2007). In a nutshell, I suggested that the 'alien' hand is no longer represented within the sensorimotor body representation in patients with somatoparaphrenia. Hence, when they are touched, they cannot localize the tactile information within this disrupted sensorimotor body representation. If the sensorimotor body representation, which is missing in somatoparaphrenic patients, is necessary for grounding bodily self-ascriptions that are immune to error, then the grounds upon which patients make their denial do not guarantee bodily IEM. I shall not pursue this line of argument here. For the sake of this paper, we may nonetheless note that the grounds upon which the patients make their judgments are not strictly similar to normal tactile experiences, at least as far as their spatial content is concerned. One is not entitled to challenge the Inside mode account of bodily IEM of self-ascriptions grounded in 'normal' tactile perception on the basis of somatoparaphrenia.

3. It's mine

“I found myself looking at the dummy hand thinking it was actually my own.” In Botvinick and Cohen (1998, p. 756)

The *Rubber Hand Illusion* (hereafter, RHI) has become *the* experimental design to artificially manipulate the sense of bodily ownership. There is no need to connect your proprioceptive system with someone else's body. All you need is to sit with your arm resting on a table, hidden behind a screen, while looking at a rubber hand presented in front of you. An experimenter then simultaneously strokes with two paintbrushes both your biological hand and the rubber hand. The illusion is three-fold:

- You feel as if you were touched on the rubber hand.
- You feel as if the rubber hand were your hand.
- You locate your hand at a location that is in between the rubber hand and your biological hand (i.e. proprioceptive drift).

There are two closely related bodily illusions manipulating the feeling of bodily ownership, but which involve the whole body. In the *Out-of-the-Body illusion*, participants wore virtual reality goggles (Lenggenhager et al., 2007). A camera projected an image of each person taken from the back and displayed six feet away. The subjects thus saw an illusory image of themselves standing in the distance. The experimenter stroked with a rod the unseen biological back while simultaneously projecting the image of the stick stroking the back of the virtual avatar in full view. When the strokes were synchronous, participants reported feeling the touch on the seen body. In addition, they reported that the seen rod was touching them and that they felt as if the seen body were their own. When passively displaced and asked to walk back to their original location, they walked too far in the direction of the location of the seen virtual body. In the *Body-Swapping illusion*, participants saw the experimenter's body with a visual perspective from above, as if looking down on their own body (Petvoka and Ehrsson, 2008). The experimenter wore two CCTV cameras, which were positioned in such a way that the images from each of them corresponded to the experimenter's eyes. The participants wore a set of head-mounted visual displays, which were connected to the cameras in such a way that the images from the left and right video cameras were presented to the participants' left and right eyes, respectively. Therefore, the participants viewed the experimenter's body from the first-person perspective, as if it were their own. They were then asked to stand opposite the experimenter and to take hold of their hand and squeeze it. In the synchronous condition, the participant and the experimenter squeezed each other's hands simultaneously, while in the asynchronous condition, they squeezed each other's hands in an alternating rhythm. Participants could thus see the experimenter's hand and their biological hand shaking, but their visual perspective was from the experimenter's point of view. After synchronous squeezing, a participant reported: "I was shaking hands with myself!"

Do those types of bodily illusion challenge the Inside mode account of bodily IEM? According to Mizumoto and Ishikawa (2005, p. 12), this type of results shows that proprioceptive-based bodily self-ascriptions depend on the identification of whose body it is:

“Thus it demonstrates the case of judgement based on somatic proprioception, which is mistaken because of misidentification, and therefore constitutes a counterexample to the immunity thesis.”

I shall argue that this conclusion results from a confusion between the way of gaining information about the bodily property and the way of identifying the body that instantiates the bodily property. By analysing a few specific examples, I shall show that bodily self-ascriptions resulting from the RHI are not grounded in ways of gaining bodily information that are classically assumed to guarantee bodily IEM.

3.1 I feel being touched on the rubber hand

Most participants report that they feel being touched on the rubber hand. Another way to phrase it in more physical terms is that they feel that their hand is in contact with the paintbrush stroking the rubber hand (hereafter, ‘rubber paintbrush’). One may propose the following reconstruction of this judgment in terms of *de re* misidentification:

- (i) Singular proposition: the rubber hand is in contact with the rubber paintbrush;
- (ii) Identity assumption: my hand = the rubber hand;
- (iii) Bodily self-ascription: my hand is in contact with the rubber paintbrush
- (iv) But actually, my hand \neq rubber hand.

The participants are correct in believing that the rubber hand is in contact with the rubber paintbrush (i), but they are incorrect about the identity assumption that the rubber hand is their own hand (ii). As such, it might be considered as a false-positive error through *de re* misidentification. If the singular proposition were grounded in somatic perception, then it would question the validity of bodily IEM. However, this is not the case. Indeed, one classical way to characterize this type of bodily illusions is in terms of *visual capture* of touch and proprioception. It is vision, rather than somatic perception, that gives the information that the bodily property is instantiated (i.e., the rubber hand is in contact with the rubber paintbrush). Somatic perception plays a role, but only at the level of the identity assumption, when it is compared to vision (i.e. temporal synchrony and spatial congruence between the visual experience and the

tactile experience). Hence, if one assumes that vision is a way of gaining bodily information that does not guarantee bodily IEM, there is no surprise that errors through *de re*-misidentification can happen. Such error through misidentification does not falsify the Inside mode account of bodily IEM.

3.2 *I am touching my own hand*

Bodily illusions that involve the full body rely on the same principle of visual capture, and thus they are not more problematical for bodily IEM than the classic RHI. The only way to avoid visual interference is to use a different type of illusion, which does not rely on visual capture of touch, that is, a non-visual version of the RHI (Ehrsson et al., 2005). In the *somatic RHI*, participants were blindfolded. The experimenter moved the participants' left index finger so that it stroked the rubber hand, and simultaneously, the experimenter stroked the participants' biological right hand in synchrony. Participants reported feeling that they were touching their own right hand. When asked to point to their right index finger after the illusion, the blindfolded participants mislocated their right hand in the direction of the rubber hand. At first sight, the somatic RHI seems to be more challenging for bodily IEM. It is not based on vision, but on touch. Yet, there are other grounds than vision that do not guarantee bodily IEM. In particular, tactile perception is ambivalent as far as bodily IEM is concerned.

Tactile perception is characterized by its duality. It carries both exteroceptive information about the external world (e.g., the ball touching my hand) and interoceptive information about the body (e.g., the pressure on my flesh). As shown by the following example, the interoceptive information guarantees bodily IEM, whereas the exteroceptive information cannot guarantee bodily IEM. Let us imagine that my left hand is anaesthetized, whereas my right hand is normal. While I am in the dark, my right hand feels a hand. Whose hand is that? I may be mistaken and judge that it is my own left anaesthetized hand, although it is someone else's hand. Nothing in my exteroceptive tactile perception guarantees that I am not mistaken about whose hand I am touching. On the contrary, I cannot be wrong about whose hand is feeling

the anaesthetized hand.⁵ Hence, only interoceptive tactile information guarantees bodily IEM.

Now in the case of the somatic RHI, the illusion concerns the touched rubber hand. The question that is asked to the participants is not whether the hand that is actively stroking the rubber hand is their own. The question is whether the hand that the participants feel under their finger tip while stroking is their own. The information they have about the rubber hand that they are touching exclusively relies on exteroceptive touch. As argued, exteroceptive touch cannot guarantee bodily IEM. Therefore, the somatic RHI is not more a counterexample for bodily IEM than the visual RHI.

3.3 Proprioceptive drift

The analysis of the previous two judgments ("I feel being touched on the rubber hand" and "I am touching my own hand"), however, does not seem to apply to what is known as the proprioceptive drift. After visual RHI, participants mislocalize their own hand when asked to indicate its location (i.e. proprioceptive drift). They do so without seeing their own hand or the rubber hand. One may thus assume that their way of gaining information about the hand location is grounded exclusively on proprioception, with no visual interference. If so, it might constitute a "case of judgement based on somatic proprioception, which is mistaken because of misidentification, and therefore constitutes a counterexample to the immunity thesis", as argued by Mizumoto and Ishikawa (2005, p. 12).

However, this is misleading. After a few minutes without moving, the quality of the proprioceptive signal becomes very low. In the RHI, spatial judgments on the location of the hand are grounded not only in weak proprioceptive information, but also in visual memories about the location of the rubber hand. Hence, this is not a classical case of proprioception-based judgment. The judgment is based on the integration between visual information and proprioceptive information. The combination of the two ways of gaining information is revealed in the experimental results. Unlike the localization of their tactile sensations, the participants do not

⁵ At least, under normal circumstances. As suggested in the previous section, if I were somatoparaphrenic, this would no longer be true because my interoceptive tactile experience would lack the proper spatial content.

localize their own hand at the location of the rubber hand. They localize their biological hand in between their biological hand and the rubber hand. There is actually no hand where they localize their own hand.

How to analyse this type of bodily self-ascription? Participants mislocalize their hand. But do they misidentify it as well? One thing is certain. The visual memories on the location of the rubber hand should not have been integrated with the proprioceptive information on one's own hand. But does this error deserve to be qualified as an error through *misidentification relative to the first-person*? In order to reply, one needs first to evaluate the implications of multimodal bodily self-ascriptions for bodily IEM.

To conclude, I have reviewed two types of errors through bodily misidentification: somatoparaphrenia as a case of false negative, and the RHI, as a case of false positive. None of them constitutes evidence against the traditional account of bodily IEM, but they invite us to refine which grounds can guarantee bodily IEM. Based on the analysis of somatoparaphrenia, I suggested that tactile experiences must have the right spatial content to guarantee bodily IEM. In addition, I highlighted the role of vision in bodily self-ascriptions in the RHI, which is not assumed to guarantee bodily IEM according to the Inside mode account. But is the role of vision in bodily self-ascription so unusual, restricted to bodily illusions? One may argue that bodily illusions are not merely experimental artefacts, but rather reveal a fundamental fact about bodily self-knowledge, namely, its multimodality. As we shall see in the next section, vision plays an important role in bodily self-knowledge. If so, can bodily self-ascription in non-illusory situations still be immune?

4. Multimodal bodily self-knowledge

The Inside mode account of bodily IEM does not only predict that there cannot be any error through misidentification for a certain type of bodily self-ascriptions, it also assumes that somatic perception is the “normal” or the “ordinary” way of gaining bodily self-knowledge. However, recent empirical findings have shown that the normal way of gaining bodily self-knowledge is not somatic perception *per se*, but rather the integration of somatic perception with vision. Bodily self-knowledge is

primarily multimodal.⁶ But if bodily self-ascriptions are grounded not only in somatic perception, which secures bodily IEM, but also in vision, which is not supposed to secure bodily IEM, then can one still claim that bodily self-ascriptions are immune to error? Put another way, is bodily IEM restricted to a narrow range of bodily self-ascriptions exclusively based on somatic perception?

What is at stake here is how to determine what grounds guarantee bodily IEM, and what grounds do not guarantee bodily IEM.⁷ On a radical version, one may defend what I call the exclusive thesis: self-ascriptions are immune if they are *exclusively* grounded from the inside. In the light of the empirical literature on multimodality, I shall show that it would make bodily IEM a marginal phenomenon. I shall reject the exclusive thesis on the basis of two complementary arguments. On the one hand, I shall rehabilitate some visual experiences such that they can guarantee bodily IEM, but under some limited circumstances only. On the other hand, I shall argue that visual interference does not systematically prevent bodily IEM because the process of visuo-proprioceptive integration can guarantee bodily IEM.

4.1 *The exclusive thesis*

Let us go back to the Inside mode account of bodily IEM. This view assumes a traditional dichotomy between somatic perception and vision (or perception from the inside and perception from the outside). On this view, only the former guarantees bodily IEM. Hence, bodily self-ascriptions grounded in vision are not immune to error. Unfortunately, the traditional account does not raise the question of bodily self-ascriptions that are grounded both in somatic perception and in vision. As vision does not secure bodily IEM, one may conclude that vision can contaminate the judgments it leads to, even if those judgments are also based on proprioception. This is what I shall call the *exclusive thesis*. According to the exclusive view, bodily self-ascriptions are immune to error if and only if (i) they are based on somatic perception and (ii) there is no further ground. Consequently, bodily self-ascriptions are either immune to

⁶ For sake of clarity, I call multimodal the integration between vision and somatic perception.

⁷ I shall focus on the perceptual grounds of bodily self-knowledge. There is, however, another source of information about one's body, namely, efferent information that one has initiated a bodily movement. One may argue that judgments about bodily movements grounded in efferent information are immune to error through misidentification. But I shall not go into the detail of this proposal here. I shall also leave aside here the distinction between which-misidentification and de re-misidentification.

error or multimodal. On this view, the extent of bodily IEM is determined by the extent of multimodality: the more multimodality, the less bodily immunity.

There are many ways vision influences and interferes with somatic perception at a very early stage in sensory processing (Calvert et al., 1998), and I shall not review them here. Rather, I would like to emphasize that multimodality is not merely anecdotal. The influence of external perception on somatic perception plays both an epistemic role and a pragmatic role. Vision plays an epistemic role because it maximizes the accuracy of spatial information. Several studies have shown that the visual occipital areas in the brain are specialized in high-acuity spatial processing such that they are recruited even by purely tactile tasks (for review, see Sathian et al., 2004). For instance, the temporary inhibition of the occipital areas by TMS disrupts tactile perception of grating orientation. Vision is also more reliable than proprioception at determining spatial information (Welch and Warren, 1986).⁸ If visual information and proprioceptive information about hand location are in conflict, the visual modality usually dominates such that the judgment on hand location relies more on visual signals than on proprioceptive ones. For instance, when people view their hand through optical prisms that shift the direction of light rays by a constant angle, they experience a conflict between the seen and the felt position of their hand. After a certain time of adaptation, people no longer make two distinct judgments on the position of their hand, respectively grounded in vision and in proprioception. Rather, they report *seeing* and *feeling* their hand somewhere between the two positions where the hand is perceived on the basis of vision only and proprioception only. Hence, the participants' proprioceptive judgment is grounded in both external and internal information about the hand location. Furthermore, the hand is usually localized closer to the visually perceived position than to the position proprioceptively perceived. Prism adaptation highlights the early integration of the two information channels because it introduces an artificial conflict. But it can be generalized to many bodily judgments in everyday life.

Vision also plays what might be called a pragmatic role. Bodily self-knowledge is required to interact with the external world, and the world is given to us mainly

⁸ But it is not a general rule. According to an optimal integration model, the specific weight of each modality depends on its precision (van Beers et al., 1999). For instance, the proprioceptive weight is larger than the visual weight when the hand is actively moving and for certain spatial directions (e.g., depth) (Van Beers et al., 2002).

through vision. In order to grasp the glass in front of me, I need to locate my hand relative to the glass in the environment where there can be obstacles to avoid. The body is embedded in its environment, and the perception of the body from the inside needs to be remapped within the external frame of reference provided by vision to interact with the environment. Hence, one needs to integrate proprioception, touch and vision for action control. As Bermudez (1998, p. 140) notes:

“To reach out for an object successfully, for example, one has to integrate visual perceptions of the object (and one’s own hand) with the proprioceptive feedback, tactile and otherwise, about limb position and movement and with the experienced shape of the object. Even movements as simple as this would pose enormous computational demands if the thesis of the modality specificity were correct. There is, however, powerful empirical evidence that the perceptual information systems subserving perceptual experiences are not, in fact, modality-specific.”

What may be the most salient illustration of the fundamental importance of vision for somatic perception is that visual information influences proprioception and touch, even if there is no on line visual signal currently available. This influence may be via visual memories (e.g., proprioceptive drift in the RHI) or via visual prediction. When one moves one's hand, one systematically predicts the sensory consequences of one's movements, making thus both proprioceptive and visual predictions of the expected location of the hand. This is true even if the movement is performed with eyes closed. In Smeets and coll. (2006), participants were asked to close their eyes, then to move their hand and to localize their hand with their eyes still closed. The authors found that the judgment of the hand location took into account not only the proprioceptive information, but also the predicted visual outcome. Hence, even with eyes closed, proprioceptive judgment about hand location is influenced by vision.

Consequently, the extent of multimodality is pervasive. It may be hard to quantify it exactly, but electrophysiological studies in rats and in monkeys have found up to 80% of the neurons in the colliculus, the putamen, the premotor and the parietal cortex that reply both to visual and to somatosensory stimuli (Duhamel et al., 1997; Graziano, Cooke et Taylor, 2000). As Bermudez (1998, p. 141) says, “it is in fact very rare that we have modality-specific perceptions”, and the perception of one's body is no exception. We cannot neglect the preponderant role of external perception in our

understanding of bodily self-knowledge. There is no dichotomy between two well-separated classes of bodily self-ascriptions, one grounded in external perception and one grounded in internal perception. On the contrary, the various information channels are often melted into a single percept.

Hence, if one defends the exclusive thesis, then the scope of bodily IEM is restricted to a limited range of bodily self-ascriptions. As such, this restriction may not be a source of concern. Arguably, it suffices that *some* bodily self-ascriptions at least are immune to error for many psychological purposes. Alternatively, one may reject the exclusive thesis. I shall show in the following sections that the interference of external perception does not always prevent bodily IEM.

4.2 Looking down

What is required is a finer-grained analysis of the grounds, not in terms of perceptual access, but in terms of the content of perceptual experiences. If so, some visual experiences might lead to judgments that are immune to error. The question then is how to draw the line between the visual content that can guarantee bodily IEM and the one that cannot. I shall argue that *visual experiences of the external world* can guarantee the IEM of certain classes of bodily self-ascriptions if they represent the environment within an egocentric frame of reference. Furthermore, I shall argue that *visual experiences of one's body* can guarantee bodily IEM if they represent the body from a self-specific first-person visuo-spatial perspective.

Let me start with visual experiences of the external world. The psychologist Gibson was maybe the strongest opponent to the classical dichotomy between vision and proprioception. He argued that even when we are looking at the external world, our visual experiences carry information about our own body:

"I maintain that all the perceptual systems are propriosensitive as well as exterosensitive, for they all provide information in their various ways about the observer's activities... Information that is specific to the self is picked up as such, no matter what sensory nerve is delivering impulses to the brain" (Gibson, 1979, p. 115)

Hence, on his view, all perception involves co-perception of the self and the environment. For instance, rapid expansion of the entire optic array indicates that we are moving toward a surface; lateral flow specifies movement parallel to a wall.

Through self-specifying invariants in the optical flow of visual information, we can thus see whether we are moving, even if we do not directly see our body moving. Gibson called this phenomenon "visual kinesthesia", and he argued that visual kinesthesia should be recognized along with muscle-joint kinesthesia in our knowledge of bodily movements. One can thus induce the illusion of moving by manipulating the information in the optical flow. In the so-called 'moving-room' experiments, participants are placed in rooms whose walls and ceilings can be made to glide over a solid and immovable floor. Participants cannot see their feet or the floor. When the walls moving backward and forward, the participants experience as if they were moving back and forth. Based on their visual kinesthesia, the participants can doubt whether they are moving or not. But they cannot doubt whether it is their own body that experience as moving back and forth. Arguably, visual kinesthesia grounds judgments about one's bodily movements that are immune to error through misidentification (Bermudez, 1998).

Visual experiences of the environment can guarantee the IEM of a second class of bodily self-ascriptions, namely, self-locating judgments. However, this is true only for visual experiences that represent the environment within an *egocentric frame of reference*. The visual location of an object can be encoded in relation to either the perceiver's spatial position or the spatial position of some other object independent of the perceiver. The former frame of reference centred on the perceiver is egocentric, whereas the latter frame of reference, which depends neither on the presence of the perceiver nor on her location, is allocentric. The egocentric perspective carries self-specifying information about the location of the perceiver. Hence, when I have the visual experience of a tree in front of me, I am entitled to judge that I am standing in front of a tree. It may not be a tree, but a painting that is in front of me. But, as noted by Evans (1982, p. 222), I cannot have the following doubt: "someone is standing in front of a tree, but is it I?". Evans concludes that visual experiences of the external world from an egocentric perspective guarantee the IEM of self-locating judgments.

Hence, visual experiences of the environment can ground judgments about the movements and the location of one's body within the environment. That visual experiences of the environment can ground bodily IEM is one thing, but that visual experiences of the body can ground bodily IEM is another thing, and this latter type of visual experiences is what is at stake in the Rubber Hand Illusion, and more

generally in multimodal bodily self-knowledge. The multimodality thesis threatens bodily IEM because external perception of one's body is not supposed to guarantee IEM, at least according to the Inside mode account. Through vision, one has access to one's body as well as to other people's bodies such that there is a gap between visually knowing that a body is F and visually knowing that it is my own body that is F. Most examples in the literature appeal to mirrors to disqualify vision. True, I can misidentify my body when I see it in a mirror. However, one might wonder whether vision of the body in some more natural circumstances cannot guarantee IEM.

Here it may be helpful to go back to the causal explanation of bodily IEM of proprioceptive judgments. As said earlier, proprioceptive experiences guarantee bodily IEM because the proprioceptive neural system is connected only to one's own body. Hence, proprioception guarantees bodily IEM because of some anatomical facts about the human body. In the same way, one may suggest that there are some other anatomical facts that secure the link between some visual contents and one's own body. For instance, one may be able to see one's nose, if one closes one eye for instance. I cannot doubt that this is my own nose when I see my nose from this specific angle. Consequently, the visual experience that represents the nose with this visuo-spatial perspective guarantees judgments about one's nose that are immune to error through misidentification. We may want to generalize this account beyond the nose. On this view, there are some visual experiences of the body represented from a certain angle at a certain distance (i.e. visuo-spatial perspective) that guarantee bodily IEM. This is due to the fact that the representation of the body from this specific visuo-spatial perspective is self-specific. Put another way, it is anatomically impossible that it could be another individual's body that I could see from this angle at this distance.⁹ Hence, there are some visuo-spatial perspectives one has on the body such that one cannot doubt that the body is one's own.

It is important here to note that self-specific visuo-spatial perspective differs from egocentric spatial frame of reference. For instance, the egocentric frame encodes the *location* of the hand relative to the perceiver, no matter the *angle* and the *distance* the hand is seen from. Indeed, the hand represented in relation to the perceiver can be seen from various angles (e.g., fingers pointing towards oneself) and it can be located

⁹ It may be possible only with some artificial tricks like in the body-swapping illusion. But this cannot constitute a counterexample given that it involves a deviant causal chain between the body that is seen and the visual experience (e.g., virtual reality system).

at various distances from the perceiver (e.g., on the other side of the room). It may even be another individual's hand. Other people's bodies are like any non-bodily objects in the environment. I can, and sometimes even need, to locate another individual's body relative to me. For instance, if I want to shake your hand, I need to visually locate your hand relative to mine. I thus represent *your* hand within an egocentric spatial frame. Consequently, the notion of egocentricity does not suffice for visual experiences of the body to guarantee bodily IEM.

A more relevant notion may be the notion of first-person visuo-spatial perspective. We can contrast the fact of seeing a body from above with the fact of facing a body. For instance, a body part, such as a foot, may be observed from a third-person perspective (e.g. toes pointing toward oneself) or from a first-person perspective (e.g. toes pointing forward). To illustrate the distinction between the two kinds of visuo-spatial perspectives, we may draw the parallel with two kinds of self-portrait. Most self-portraits are what the artist looks like from several feet – she looks in a mirror and draws what she sees there. This is for instance the case in all Van Gogh's self-portraits. There is, however, another kind of self-portrait. Ernst Mach drew himself without using a mirror – he drew what he looked like from his own point of view, from zero distance. His self-portrait is faceless, as if the universe were growing out of him. Both types of self-portrait represent one's own body, but from a different visuo-spatial perspective.

However, visual experiences of the body from first-person perspective are not necessarily visual experiences of one's own body. First-person visuo-spatial perspective is a necessary requirement for visual experiences of the body to guarantee bodily IEM, but it is not a sufficient condition. For instance, I can see a hand in front of my eyes from the right angle and the right distance if it were my own hand, but it belongs to someone else who is standing just behind me. Similarly, the visual experience of the rubber hand is from a first-person perspective, but it is not part of my body. Hence, one should distinguish between three classes of visuo-spatial perspective. First, there are visual experiences from a *third-person perspective* when one sees one's body in the way other people see it from the outside, for instance when facing one's reflection in a mirror (e.g. the visual experience of one's toes pointing toward oneself). Second, there are visual experiences from an *unspecific first-person perspective* when one sees one's body at a location and with an angle that are

compatible both with one's body and with other bodies under certain circumstances (e.g., the hand in front of my eyes). Third, there are visual experiences from a *self-specific first-person perspective* when one sees one's body at a location and with an angle that are compatible only with one's body (e.g., the visual experience of my nose when I close one eye). Within this taxonomy, one may suggest that Mach's visual experience of his body below him is from a self-specific first-person perspective. It is biologically impossible that he sees someone else's body under ordinary circumstances. If so, he would be entitled to believe that this is his own body without identifying this body as his own. Evans seems to be sympathetic with this view. He briefly suggests in a footnote to include in the list of appropriate grounds for bodily IEM the movement of "looking down to one's body" (p. 220 ft 26).

To conclude, I have argued that there is a class of visual experiences of the body represented from first-person visuo-spatial perspective that are self-specific thanks to some anatomical constraints. Only one's own body can be visually perceived in such a way. Consequently, this class of visual experiences of the body guarantees bodily IEM. Hence, one should not rule out all visual experiences as appropriate grounds for bodily IEM. There are some visual experiences that secure bodily IEM. They can be of the external world, or they can be of the body.

4.3 Multimodal integration

To recap, some bodily self-ascriptions are fundamentally multimodal. They can be grounded in vision even in the absence of current visual signal. This may limit the importance of bodily IEM (i) if vision cannot guarantee bodily IEM or (ii) if vision can 'contaminate' judgements that are also grounded in proprioception. In the previous section, I argued that thanks to anatomical constraints, there is a class of visual experiences that lead to bodily judgments that are immune to error. Nonetheless, this class is limited. Bodily self-knowledge most probably derives also from visual experiences that do not guarantee bodily IEM, such as visual experiences of the body from a unspecific first-person perspective. What are the consequences then for multimodal judgments? What is the epistemic status of those bodily self-ascriptions that are grounded both in proprioceptive experiences, which guarantee bodily IEM, and visual experiences that do not guarantee bodily IEM?

In order to assess the immunity of visuo-proprioceptive integration-based judgments, one needs to understand the basic principles of multisensory integration.¹⁰ Multisensory integration describes interactions between redundant signals. The sensory signals that are integrated carry information about the same property instantiated by the same object (e.g., location of one's hand via vision and proprioception). What is thus required is to select the relevant sensory signals that come from a common source, and to segregate them from those that come from a different source. We can summarize this requirement as follows:

The Common Source principle: Only signals that are assigned to the same source are integrated together.

Let us now consider visuo-proprioceptive integration. It requires visual and proprioceptive signals to be assigned to the same body. Proprioception *de facto* carries information only about one's own body. Hence, to be integrated with proprioceptive signals, visual signals must be "tagged" as carrying information about one's own body. If not, visual signals could not be integrated with proprioceptive signals. Under normal circumstances, the process of assignment to a common source is reliable. The fact of the matter is that we do not integrate visual information from other people's bodies with proprioceptive information from our own body, except in some artificially induced bodily illusions. This does not mean, however, that the assignment process is infallible. It may happen that visual information about a rubber hand is integrated with proprioceptive information about one's hand because visual information is mistakenly assigned to the same hand as proprioceptive information. Consequently, there can be errors. But are they errors through *misidentification relative to the first-person*?

One way to interpret the assignment mechanism that guarantees that only the relevant inputs from the same source are integrated together is in terms of identification. Hence, one may argue that the Common Source principle implies that multimodal self-ascriptions are identification-dependent. In other words, one would need first to identify whose body one is seeing before integrating the visual information with the proprioceptive information. Therefore, one could misidentify the

¹⁰ Multisensory integration should not be confused with multisensory combination (Ernst and Bühlhoff, 2004). *Multisensory combination* describes interactions (e.g., cooperation and disambiguation) between sensory signals that are not redundant. The sensory signals that are combined carry information about different properties of the same object, or about different objects.

seen body and integrate visual information from a different body with proprioceptive information from one's own body. This view, however, is misleading. Multimodal integration does not require that the subject feels that her body is F, sees that *x* is F, judges that *x* is her body, and integrates what she feels with what she sees. There are two reasons why this is not the correct reconstruction of the integrative process.

First, what is prior to the integrative process is not accessible to the subject. As mentioned before, multimodal integration occurs very early on in the perceptual process. The integration is made at a primary perceptual level, so primary that the subject cannot have access to the raw modality-specific perception. Rather than identification, one may rather talk of a subpersonal process of assignment (Deneve and Pouget, 2004). More importantly, multimodal integration does not require *self*-identification. It is important here to go back to Shoemaker's original motivation for the hypothesis of IEM. Shoemaker argues that there must be some self-ascriptions that do not depend on self-identification to avoid infinite regress. Let us consider that all self-ascriptions are identification-dependent. If so, the judgment 'I am F' is grounded in the proposition '*x* is F' and the identity assumption 'I am *x*'. But the identity assumption itself constitutes a case of self-ascription that requires an identification component, which in turn shall also require an identification component, etc. Hence, self-identification leads to infinite regress. In order to avoid infinite regress, there must be self-ascriptions that do not depend on self-identification, and thus that are immune to error through misidentification relative to the first-person.

The main target for Shoemaker is not identification *per se*, but rather *self*-identification, and self-identification is not required by the Common Source principle. As said earlier, it is not as if the visual system had to identify the seen body as one's own body. Rather, the assignment of a common source to the various sensory signals relies on a comparison between sensory signals, not on self-identification for each sensory signal. The psychological literature is not clear yet on the principles guiding the mechanism of assignment (this is known as '*the assignment problem*', cf. Pouget et al., 2004). Nonetheless, we already know that spatio-temporal consistency between visual and tactile information is a necessary, although not sufficient, condition. This is why the RHI works only if the stroking on the rubber hand is synchronous with the stroking of the biological hand and if the rubber hand is not too far from the biological hand, and with the same orientation. As interesting as they are, the

assignment principles are not at stake in the hypothesis of bodily IEM. The hypothesis of bodily IEM concerns the possibility of error through misidentification relative to the first-person (i.e. self-misidentification), whereas the Common Source principle concerns the assignment to a common source via subpersonal comparison of visual and proprioceptive (or tactile) experiences, which does not depend on self-identification.

In a nutshell, (i) only signals assigned to a common source are integrated together, (ii) the assignment to a common source results from a subpersonal comparative process that does not depend on self-identification, and (iii) proprioceptive signals are only from one's own body. Combined together, these three principles guarantee that bodily IEM is preserved in integration-based bodily self-ascriptions. It might happen that the assignment process fails, resulting for instance in the proprioceptive drift in the RHI. Yet, the proprioceptive drift cannot be assimilated to an error through misidentification relative to the first-person.

To conclude, one should not accept the classical dichotomy between the immunity-preserving somatic perception and the vulnerable vision. Nor should one assume the exclusive thesis such as only the judgments that are exclusively grounded in somatic perception are immune to error. Rather, I propose to extend the list of grounds appropriate for bodily IEM to include visual experiences of the environment within an egocentric frame of reference, visual experiences of the body from a self-specific first-person perspective and experiences resulting from the integration of vision and somatic perception.

Conclusion

Recent empirical insight in the nature of bodily self-knowledge sheds new light on bodily IEM, and more specifically on the grounds that can guarantee bodily IEM. False negatives like somatoparaphrenia and false positives like a series of bodily illusions do not constitute valid counterexamples for the principle of bodily IEM. Nonetheless, they invite us to offer a finer-grained analysis of the grounds that are appropriate for bodily IEM, and those that are not. In particular, the analysis should not take place merely at the level of the individuation of the sensory modalities *per se*

(e.g. proprioception versus vision), but rather at the level of the content of the perceptual experiences. This opens the possibility for some visual experiences from a first-person perspective to ground judgments that are immune to error. Furthermore, most accounts of bodily IEM focus on proprioception, neglecting the multimodality of most bodily self-ascriptions. The mechanism of multimodal integration requires the assignment of the various sensory signals to a common source. Consequently, proprioceptive signals are integrated only with visual signals coming from one's body under normal circumstances. Hence, visuo-proprioceptive experiences ground judgments that are immune to error.

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